AE 8801 Bioastronautics

Bioastronautics Seminar, Fall 2024 (Credits: 1)

Wednesdays, 9:30-10:20 am, Clough 325

Instructor Information

Instructor	Email	Drop-in Hours & Location
Christopher E. Carr	cecarr@gatech.edu	[redacted]
Teaching Assistant(s)	**Email**	**Drop-in Hours & Location**
Not applicable (N/A)	N/A	N/A

General Information

Description

Bioastronautics Seminar surveys the past, present, and future of human spaceflight through the lens of human adaptation to extreme environments, exploring the limits and augmentation of human performance. This course aims to introduce, at the graduate level, critical history, current knowledge, and unknowns related to human exploration of space, including in weightlessness, the moon, and Mars. With a return to the moon underway by NASA and multi-country exploration of the moon and Mars underway, this timely course will introduce key history and literature, quantitative physiology, bioenergetics, manual control, and other areas of relevance as humans venture beyond low Earth orbit.

Enrollment will be capped at 20 people to facilitate group discussion.

Pre- &/or Co-Requisites

There are no formal pre-requisites other than graduate status. However, relevant background includes: thermodynamics, fluid dynamics, physics, dynamics, biology, structures, human factors, and many more areas. The main requirement is a willingness to read, learn, and contribute.

Course Goals and Learning Outcomes

Upon successful completion of this course, you should be able to:

- Describe the historical context in which bioastronautics knowledge has been developed.
- Explain the basis for physiological effects of spaceflight on the human body from a conceptual and quantitative manner, utilizing engineering tools to understand human adaptation and performance in space and planetary environments.
- Evaluate and analyze human space systems required to support human activity in space, including intravehicular and extravehicular activity, life support, and environmental control.
- Identify open questions in bioastronautics that are timely and relevant to human exploration and habitation beyond Earth, including on the Moon and Mars.

Course Requirements & Grading

Assignment	Date	Weight
Participation	All classes	50% (as measured by surveys and based in part on reading papers and participating in class discussions)
Individual Assignments	A few short assignments	25%
Mini Project	End of semester	25% (based on small group project)

To succeed in this course, do the reading, show up, participate actively, and make some contributions through your assignments and mini projects, which will be short focused activities related to advancing bioastronautics at Georgia Tech and beyond.

Extra Credit Opportunities

Extra credit will be considered on a case-by-case basis.

Description of Graded Components

Students are expected to contribute actively in class through discussions and group work. Typically, each class will have a brief survey as a measure of attendance and may also have a short quiz. There will be several individual assignments related to didactic learning in the course. The portfolio assignment (format to be provided) will be an edited compilation of individual contributions to the mission design aspect of the course; for this reason, I recommend that you keep a written record of your learning and contributions in the course that can be used to support your portfolio.

There will be no midterm and no final exam. In lieu of a final exam, there will be a final presentation and final report completed by groups or sub-groups as part of their contribution to the overall mission design goal. Templates and rubrics will be provided. These presentations and reports are nominally expected to be due up to and including the final instructional day.

Extensions may be granted in cases where extenuating circumstances prevented the student from reasonably completing an assignment on time. Examples include illness, emergencies, family situations, and institute excused absences. The Office of the Vice President and Dean of Students can assist students with documented emergencies by contacting professors on behalf of the student. You can get more information on this process here: https://studentlife.gatech.edu/content/class-attendance. If you know you will need an extension, please be proactive and reach out ahead of time, not after the due date.

If you have internet or technical difficulties that prevent you from uploading to Canvas on time, please send a text message or email to the TA and instructor immediately to document this, and then upload as soon as you are able.

Grading Scale

Your final grade will be assigned as a letter grade according to the following scale:

A	90-100%
B	80-89%
C	70-79%
D	60-69%
F	0-59%

Course Materials

Course Text

No textbook is required. Course materials have been selected from those available via Georgia Tech's library and/or the public domain, and selected materials are listed below.

Young LR, Sutton JP. **Handbook of Bioastronautics** (2021). Available via Georgia Tech library as PDF. https://link.springer.com/referencework/10.1007/978-3-319-12191-8.

Maresh RW, Woodrow AD, Webb JT (2016). **Handbook of Aerospace and Operational Physiology, 2nd Edition.** Air Force Research Laboratory, AFRL-SA-WP-SR-2016-0018. Publicly available at: https://apps.dtic.mil/sti/pdfs/AD1020889.pdf

R. S. Johnston, L. F. Dietlein, C. A. Berry, J. James F. Parker, V. West, W. L. Jones, **Biomedical Results of Apollo** (1975). https://ntrs.nasa.gov/citations/19760005580.

Jones EM. Apollo Lunar Surface Journal. https://www.nasa.gov/history/alsj/

Jack W. Stuster. **Bold Endeavors: Lessons from Polar and Space Exploration** (2011). Available via Georgia Tech library as PDF and EPUB.

National Academies (2023). **Thriving in Space: Ensuring the Future of Biological and Physical Sciences Research: A Decadal Survey for 2023-2032**. https://www.nationalacademies.org/our-work/decadal-survey-on-life-and-physical-sciences-research-in-space-2023-2032

Mars Design Reference Mission 5.0, NASA-SP-2009-566 https://www.nasa.gov/wp-content/uploads/2015/09/373665main_nasa-sp-2009-566.pdf

E. Afshinnekoo, R. T. Scott, M. J. MacKay, E. Pariset, E. Cekanaviciute, R. Barker, S. Gilroy, D. Hassane, S. M. Smith, S. R. Zwart, M. Nelman-Gonzalez, B. E. Crucian, S. A. Ponomarev, O. I. Orlov, D. Shiba, M. Muratani, M. Yamamoto, S. E. Richards, P. A. Vaishampayan, C. Meydan, J. Foox, J. Myrrhe, E. Istasse, N. Singh, K. Venkateswaran, J. A. Keune, H. E. Ray, M. Basner, J. Miller, M. H. Vitaterna, D. M. Taylor, D. Wallace, K. Rubins, S. M. Bailey, P. Grabham, S. V. Costes, C. E. Mason, A. Beheshti, **Fundamental Biological Features of Spaceflight: Advancing the Field to Enable Deep-Space Exploration**. Cell 183, 1162–1184 (2020). Open access: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8441988/

J. R. Gaier, **The Effects of Lunar Dust on EVA Systems During the Apollo Missions.** (2005). https://ntrs.nasa.gov/citations/20050160460

Aerospace Biomedical and Life Support Engineering, MIT OCW Course 16.423J, Spring (2006). https://ocw.mit.edu/courses/16-423j-aerospace-biomedical-and-life-support-engineering-spring-2006/

R. Santomartino, N. J. H. Averesch, M. Bhuiyan, C. S. Cockell, J. Colangelo, Y. Gumulya, B. Lehner, I. Lopez-Ayala, S. McMahon, A. Mohanty, S. R. Santa Maria, C. Urbaniak, R. Volger, J. Yang, L. Zea, **Toward sustainable space exploration: a roadmap for harnessing the power of microorganisms.** *Nat Commun* **14**, 1391 (2023). Open Access: https://www.nature.com/articles/s41467-023-37070-2

NASA Moon to Mars Architecture https://www.nasa.gov/moontomarsarchitecture/

Heldmann et al. **Mission Architecture Using the SpaceX Starship Vehicle to Enable a Sustained Human Presence on Mars.** *Astrobiology* (2022), https://www.liebertpub.com/doi/full/10.1089/space.2020.0058

National Academies of Sciences, Engineering, and Medicine. **A Science Strategy for the Human Exploration of Mars** (ongoing study). https://www.nationalacademies.org/our-work/a-science-strategy-for-the-human-exploration-of-mars

V. Rahimzadeh, J. Fogarty, T. Caulfield, S. Auñón-Chancellor, P. Borry, J. Candia, I. G. Cohen, M. Covington, H. F. Lynch, H. T. Greely, M. Hanlon, J. Hatt, L. Low, J. Menikoff, E. M. Meslin, S. Platts, V. Ravitsky, T. Ruttley, R. D. Seidler, J. Sugarman, E. Urquieta, M. A. Williams, P. R. Wolpe, D. Donoviel, A. L. McGuire, **Ethically cleared to launch?** *Science* **381**, 1408–1411 (2023).

A. Coustenis, N. Hedman, P. T. Doran, O. Al Shehhi, E. Ammannito, M. Fujimoto, O. Grasset, F. Groen, A. G. Hayes, V. Ilyin, K. P. Kumar, C.-E. Morisset, C. Mustin, K. Olsson-Francis, J. Peng, O. Prieto-Ballesteros, F. Raulin, P. Rettberg, S. Sinibaldi, Y. Suzuki, K. Xu, M. Zaitsev, **Planetary protection: an international concern and responsibility.** *Frontiers in Astronomy and Space Sciences* **10** (2023).

Course Website and Other Classroom Management Tools

The course is managed via Canvas.

Course Expectations & Guidelines

Course Ethics

Academic dishonesty is not tolerated in any form. Students are expected to uphold high ethical standards including adherence to the Georgia Institute of Technology Honor Code. Below are some guidelines to help you understand what constitutes appropriate academic behavior:

- Students are not permitted to review or use materials from previous semesters. This includes the use of old assignments.
- Students are permitted and encouraged to work collaboratively on assignments and seek help from one another, but the work that is turned in must be the student's own work. Copying another student's work is not permitted.
- On group assignments, students are expected to do their fair share of the work. If there is an instance where a student is not contributing to a group project, the team members should notify the instructor as soon as possible.
- Plagiarism of any kind is not permitted. Plagiarism includes reproducing the words or visual/graphical expressions of others without clear attribution and citation.
- Allowable use of Large Language Models (LLMs) such as ChatGPT or other AI-writing tools is assignment-specific. Further guidelines will be provided during the course.

Large Language Model (LLM)/ChatGPT General Rule: All work you submit should be your own. Anything you submit should be written by you with proper citation. How to do this: 1) Never "copy" text from an AI assistant. 2) Recommendation: Do not have your assignment and the AI assistant open at the same time. *Credit:* David Joyner and Ron Mazique

This is an evolving area; while it is evolving, the above approach should be reasonably safe and will be acceptable for this course.

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit http://www.catalog.gatech.edu/policies/honor-code/ or http://www.catalog.gatech.edu/rules/18/.

Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or http://disabilityservices.gatech.edu/, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Attendance and/or Participation

This class will include both asynchronous and synchronous activities, including group activities, which are a critical part of the learning process. Active participation is expected and will contribute toward your final grade. Attendance will be verified through post-activity feedback (survey).

More than 1 unexcused absence during the semester will result in a deduction in your attendance grade for that absence. Institute approved absences will not count against you, and reasonable accommodation and exception will be made for illness and emergencies. NOTE: If you are ill, please do not attend any in person activities. Your health takes priority and your fellow students will appreciate your consideration.

Students may need to miss synchronous activities due to personal emergencies such as being hospitalized or being in a car accident. The Office of the Vice President and Dean of Students can assist with contacting professors in these situations via the link provided in the previous section. These absences will not be considered unexcused, and we will make reasonable accommodations to assist you.

If you ever find yourself in any situation in which an unexpected personal challenge is preventing you from performing your best in the course, please reach out so we can come up with a plan for you.

In the case of absence due to approved activities, illness, or otherwise, contact the instructors to develop a plan to get back on track.

See http://www.catalog.gatech.edu/rules/4/ for more information about institute expectations and restrictions around attendance, including information about excused absences.

Collaboration & Group Work

Group work is permitted and encouraged except for assignments identified as individual work.

Extensions, Late Assignments, & Re-Scheduled/Missed Exams

Assignments must be posted by the due date and time to be eligible for full credit.

A late period for late assignments will last until 6pm the day after the due date, with a 10% deduction applied to any assignment turned in during this late period. Any assignments turned in after the late period without prior approval will receive a 0.

Instead of submitting late, reach out to me ahead of time and ask for what you need.

Student-Faculty Expectations Agreement

At Georgia Tech we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See http://www.catalog.gatech.edu/rules/22/ for an articulation of some basic expectation that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Student Use of Mobile Devices in the Classroom

Please do not use mobile devices in the classroom except in a way that contributes to the academic nature of any class activities.

Additional Course Policies

Recording of Class Sessions and Required Permissions

Classes may not be recorded by students without the express consent of the instructor unless it is pursuant to an accommodation granted by the Office of Disability services. Class recordings, lectures, presentations, and other materials posted on Canvas are for the sole purpose of educating the students currently enrolled in the course.

Students may not record or share the materials or recordings, including screen capturing or automated bots, unless the instructor gives permission. Group meetings and/or video presentations may require students to engage the video camera, but those recordings will not be shared with or disclosed to others without consent unless legally permitted.

For classes where participation is voluntary, students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. For classes requiring class participation, if students are identifiable by their names, facial images, voices, and/ or comments, written consent must be obtained before sharing the recording with persons outside of currently enrolled students in the class.

Discussion Points

1. **Honesty:** The School of Aerospace Engineering values honesty and integrity of all members of our community. An important element of this value is the academic honor code.

   Georgia Tech Honor Challenge Statement: I commit to uphold the ideals of honor and integrity by refusing to betray the trust bestowed upon me as a member of the Georgia Tech community.

   Honor Code: http://policylibrary.gatech.edu/student-affairs/academic-honor-code#Article_I:Honor_Agreement

2. **Well Being:** The School of Aerospace Engineering values the complete well-being of all members of its community, which includes professional, physical, spiritual, emotional, and social dimensions. There are numerous resources to support the health and well-being of all members of our community: https://gatech.instructure.com/courses/108574

   Mental Health Resources:

   Emergencies: Can either Call 911 or call Campus Police at 404.894.2500 http://www.police.gatech.edu/

   Center for Assessment, Referral, & Ed. (CARE): https://care.gatech.edu/ 404.894.3498 (Counselor On-Call)

   Counseling Center: https://counseling.gatech.edu/ 404.894.2575

   Stamps Health Services: https://health.gatech.edu/ 404.894.1420

Student Life and Dean of Students: https://studentlife.gatech.edu/content/get-help-now 404.894.6367

Victim-Survivor Support (VOICE): https://healthinitiatives.gatech.edu/well-being/voice 404-385-4464/(or 4451)

National Suicide Prevention Lifeline: 1.800.273.TALK (8255)

Georgia Crisis and Access Line: 1.800.715.4225

3. **Social Justice:** The School of Aerospace Engineering values social justice for all members of the Georgia Tech community and the larger society. Social justice means that everyone's human rights are respected and protected. We stand committed in the fight against racism, discrimination, racial bias, and racial injustice. Our shared vision is one of social justice, opportunity, community, and equity. We believe that the diversity and contributions from all of our members are essential and make us who we are. We believe that our impact must reach beyond the classroom, research labs, our campus, and the technology we create, but must also improve the human condition where injustice lives. We will continue to work to understand, value, and celebrate all people and create an inclusive educational and work environment that welcomes all.

   As a matter of policy, Georgia Tech is committed to equal opportunity, a culture of inclusion, and an environment free from discrimination and harassment in its educational programs and employment. Georgia Tech prohibits discrimination, including discriminatory harassment, on the basis of race, ethnicity, ancestry, color, religion, sex (including pregnancy), sexual orientation, gender identity, national origin, age, disability, genetics, or veteran status in its programs, activities, employment, and admissions.

   http://policylibrary.gatech.edu/equal-opportunity-nondiscrimination-and-anti-harassment-policy

Tips for Succeeding in this Course

I will do my part to make this course a success. However, being successful will require you to do your part as well. Here are a few tips to help you be successful in this course.

- Participate fully in asynchronous and synchronous activities!
- Use office hours. If you are not available at one of these times, contact us and we will find an alternate time. Office hours are a great time to get help with homework, ask questions about the material covered in class, discuss your own performance in the course, or just to come and chat. These are a resource for you, and I encourage you to use it!
- Your peers are a resource - talking out an assignment with a classmate can be a fantastic tool to enhance learning for all parties. Explaining your thought process to someone else is often helps your brain organize and synthesize information.
- Make sure you contribute to your group projects. These are designed to help you learn the material. Plus, your peers are the first of your future professional network. Don't start off with a bad impression!

Course Schedule

See Canvas for schedule with dates, prereading, and assignments.

Class #	Topic	Reading, Notes, due dates, and more
1	History of Bioastronautics and Human Spaceflight	Prereading (to be posted on canvas)
2	Group Work	Designing Bioastronautics Program at Georgia Tech
3	Limits of Human Performance	Prereading
4	Space Environments and Adaptation	Prereading; *Deliverable 1 due*
5	Space Human Factors	Prereading
6	Extravehicular Activity: Space Suits as Specialized Spacecraft	Prereading; *Deliverable 2 due*
7	Life Support Systems; Crew Medical Systems; Space Nutrition, Food, and Waste	Prereading
8	Psychological Effects of Space Travel	Prereading; *Deliverable 3 due*
9	Space Radiation, Shielding, and Risk	Prereading
10	Human Spaceflight Ethics, Legal, and Policy Considerations	Prereading
11	Group Mini-Projects Work / OR Guest Lecture	Prereading
12	Artemis and Future Lunar Exploration	Prereading
13	Human Mars Exploration	Prereading
14	Group Mini Projects Presentations	Presentations Uploaded Before Class
	Guest Lecture: Special Topic	Not scheduled this semester